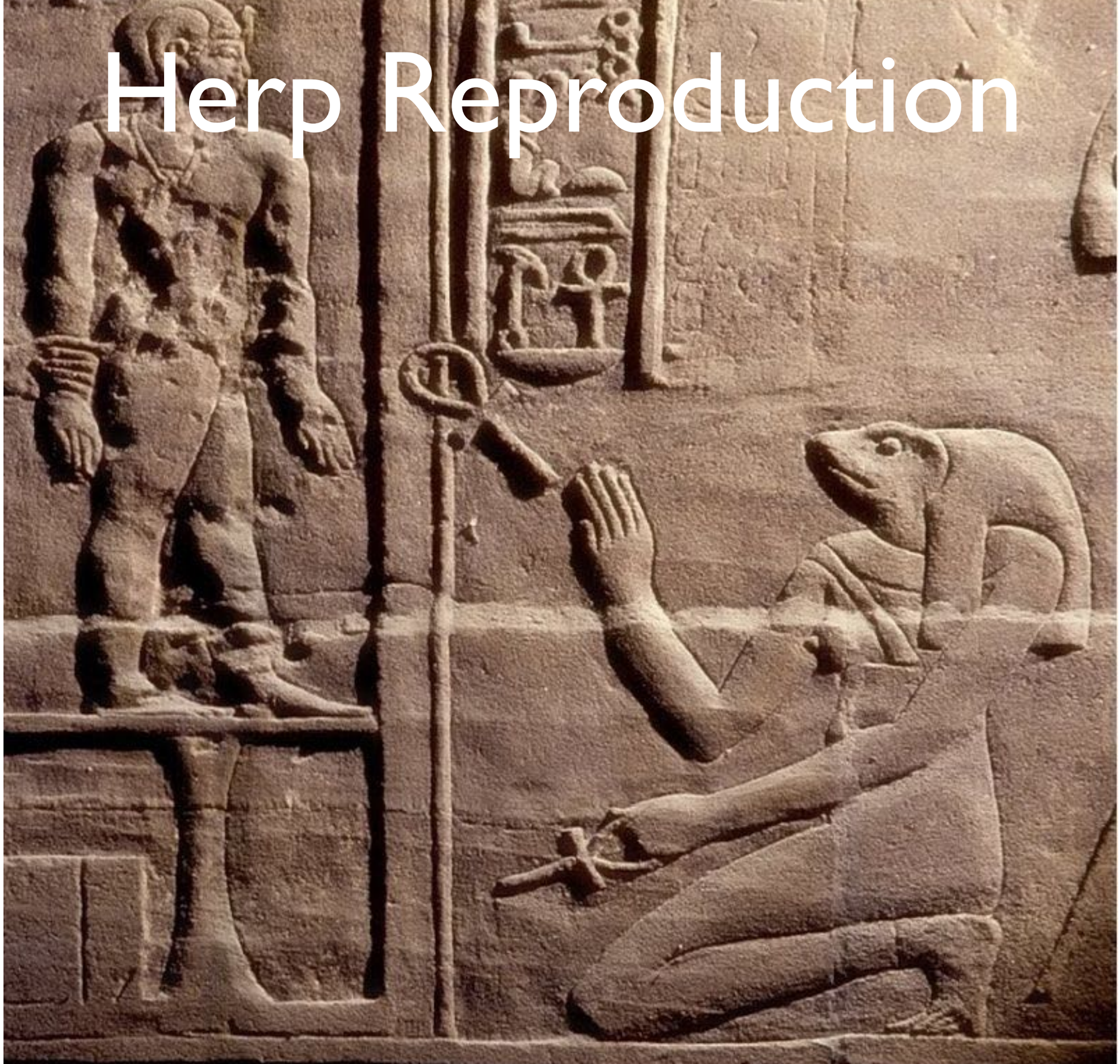
Herp Reproduction



Reproduction

- **Egg to zygote:** How do eggs get fertilized?
- **Zygote to juvenile**: What are the different herp reproductive modes?

Reproduction

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Reproductive cycles coordinate the internal processes and external events related to fertilization

Reproductive cycles coordinate the internal processes and external events related to fertilization

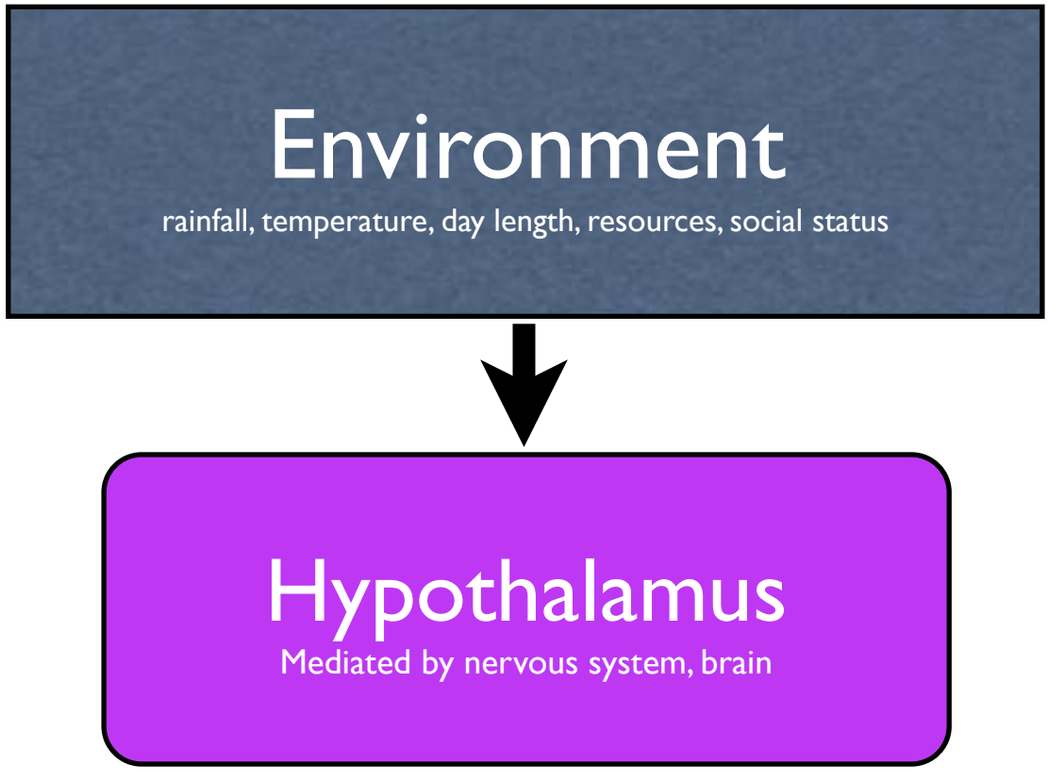
These reproductive cycles are mediated by **hormones** that respond to external stimuli

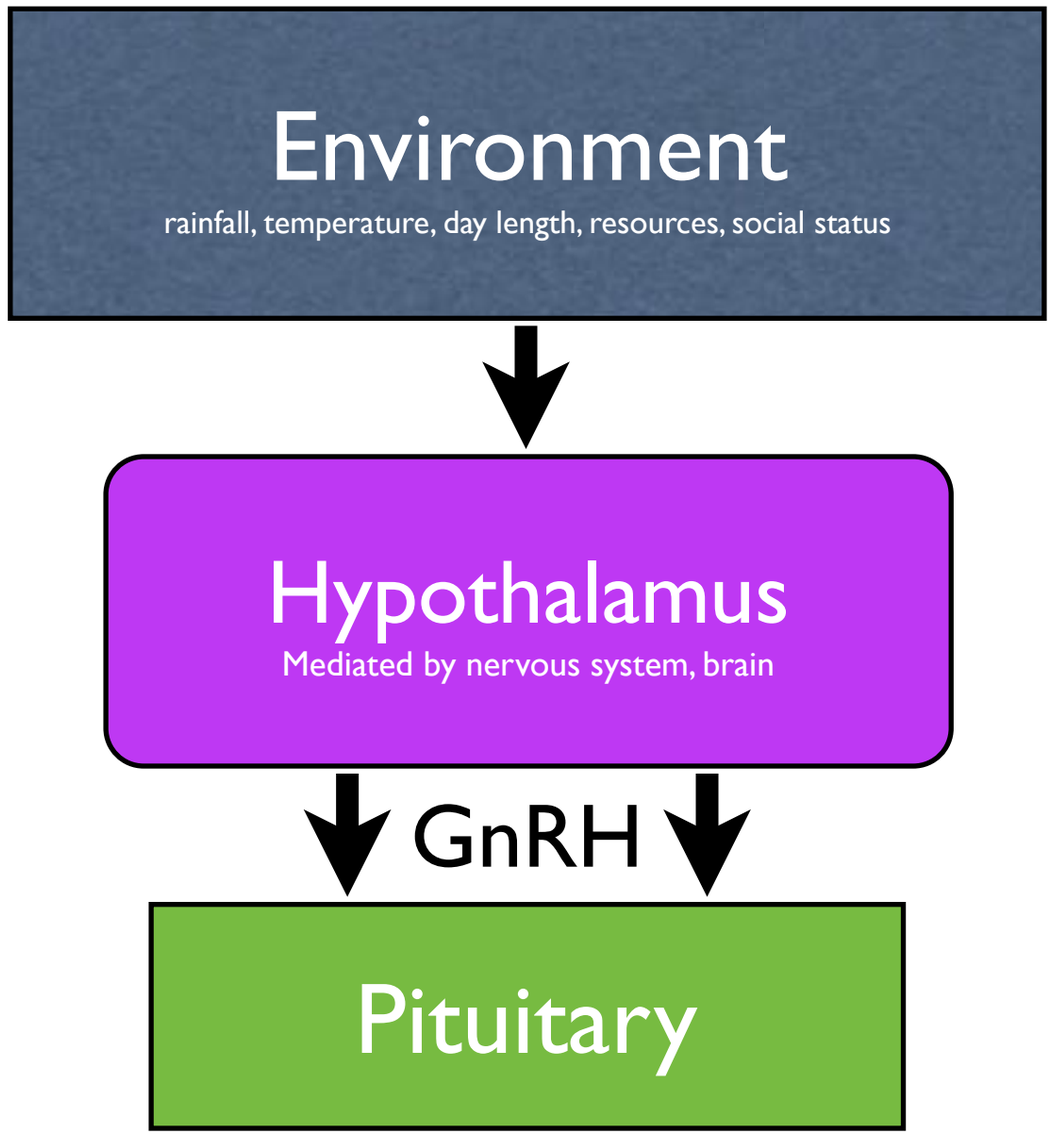
Control of Gamete Production

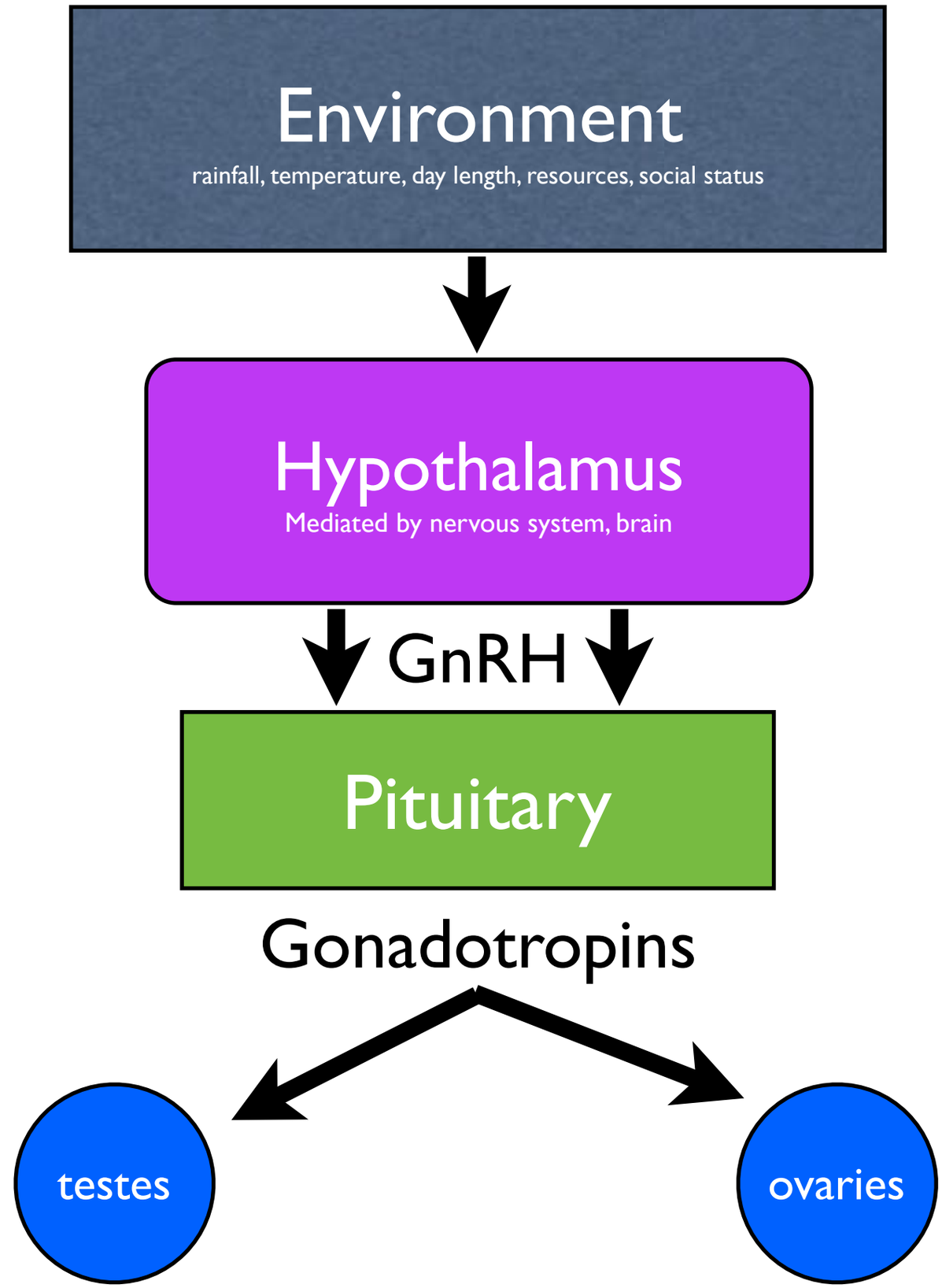
- Reproduction is triggered by environmental queues: temperature, rainfall, photoperiod
- Environmental queues stimulate hormone production; gametes are produced (gametogenesis)

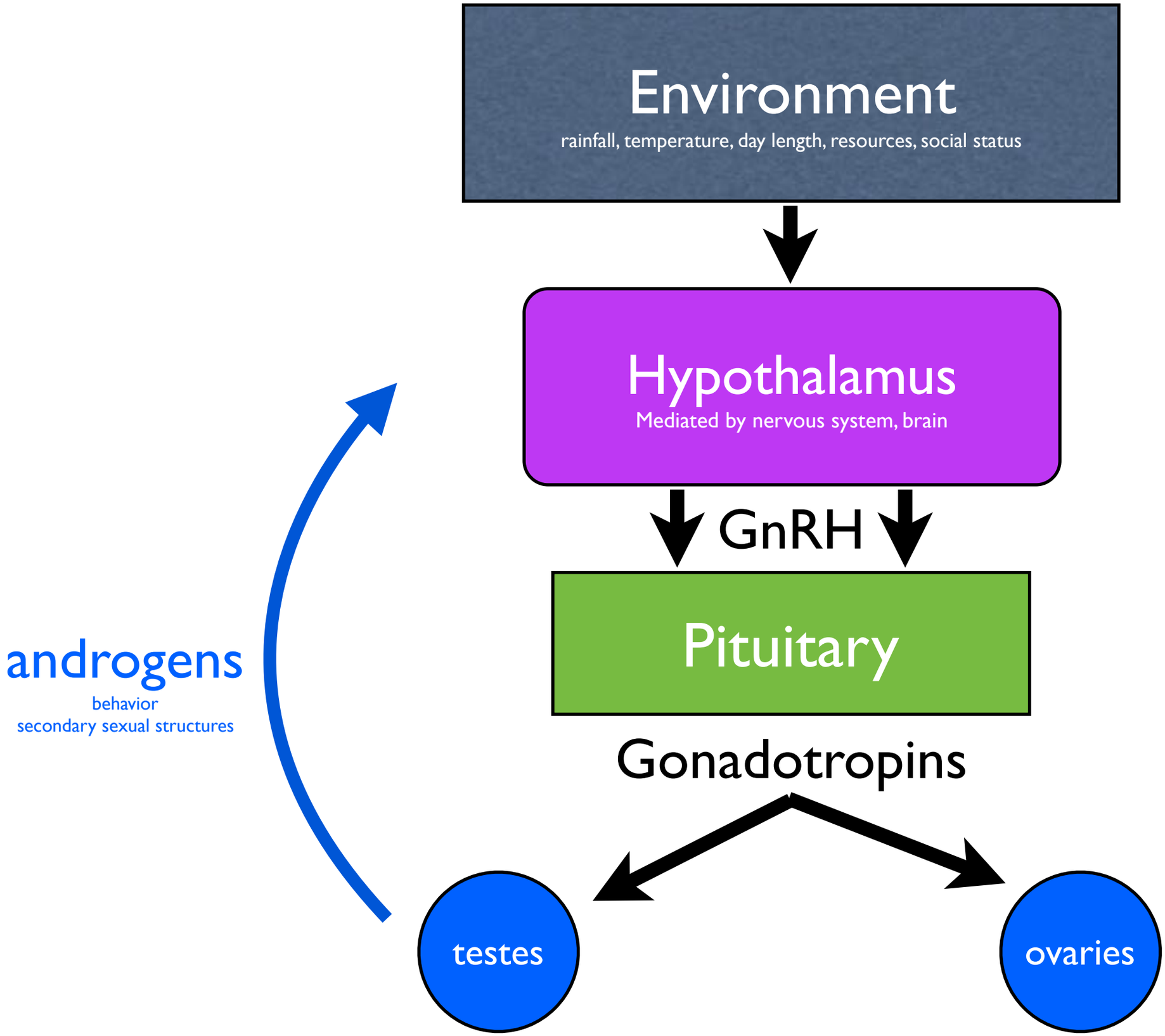
Environment

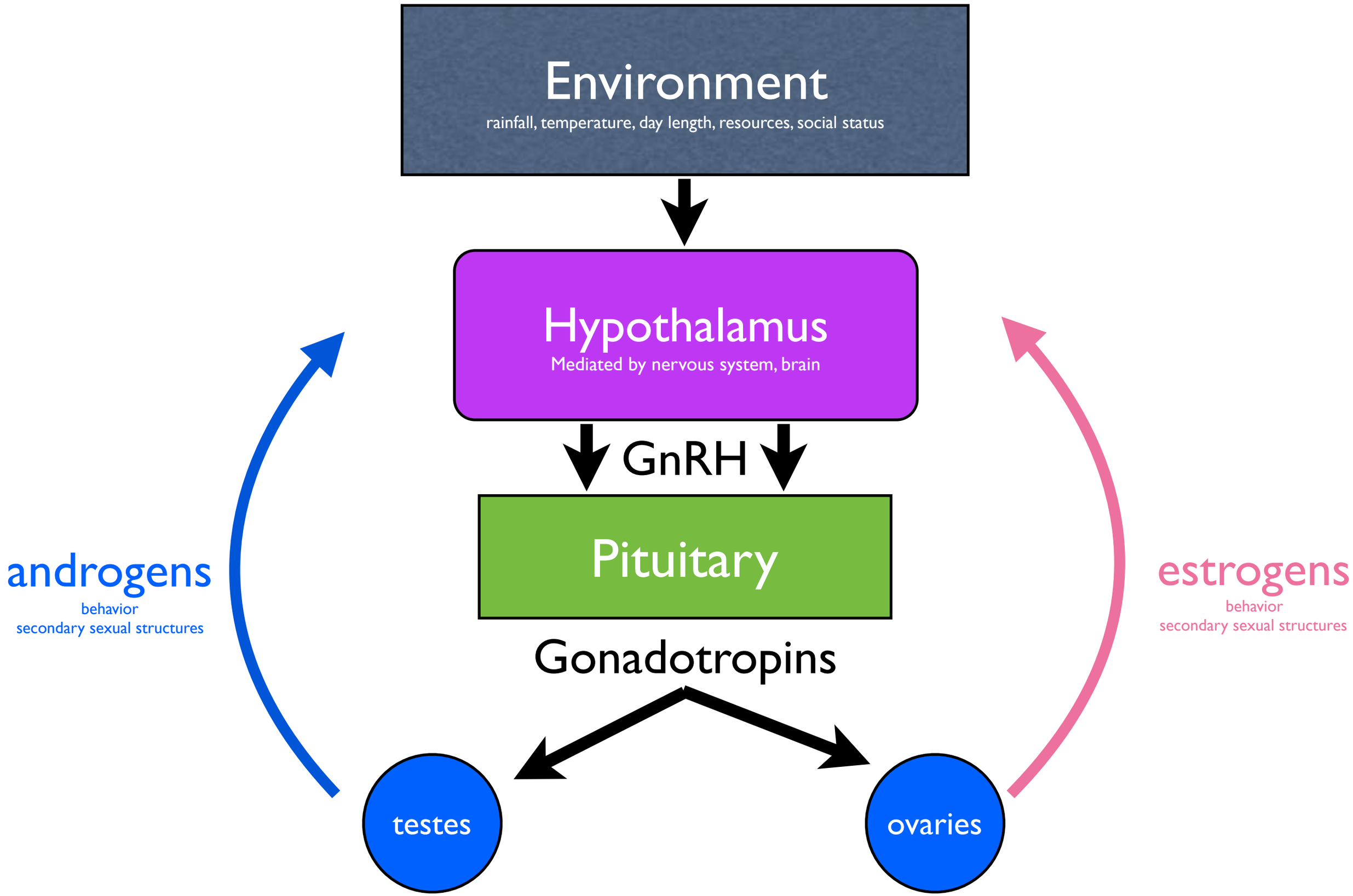
rainfall, temperature, day length, resources, social status


Environment
rainfall, temperature, day length, resources, social status
Hypothalamus
Mediated by nervous system, brain


Environment
rainfall, temperature, day length, resources, social status
Hypothalamus
Mediated by nervous system, brain
GnRH
Pituitary


Environment
rainfall, temperature, day length, resources, social status
Hypothalamus
Mediated by nervous system, brain
GnRH
Pituitary
Gonadotropins
testes
ovaries


Environment
rainfall, temperature, day length, resources, social status
Hypothalamus
Mediated by nervous system, brain
GnRH
Pituitary
Gonadotropins
testes
ovaries
androgens
behavior
secondary sexual structures


Environment
rainfall, temperature, day length, resources, social status
Hypothalamus
Mediated by nervous system, brain
GnRH
Pituitary
Gonadotropins
testes
ovaries
androgens
behavior
secondary sexual structures
estrogens
behavior
secondary sexual structures

Hormones

- **Gonadotropin-releasing hormone** (GnRH): hypothalamus, stimulates release of gonadotropins
- **Gonadotropins**: produced by pituitary, stimulate gamete production
- **Androgens**: male sex hormones
- **Estrogens**: female sex hormones

Rana esculenta - the (unfortunately named) “edible frog”

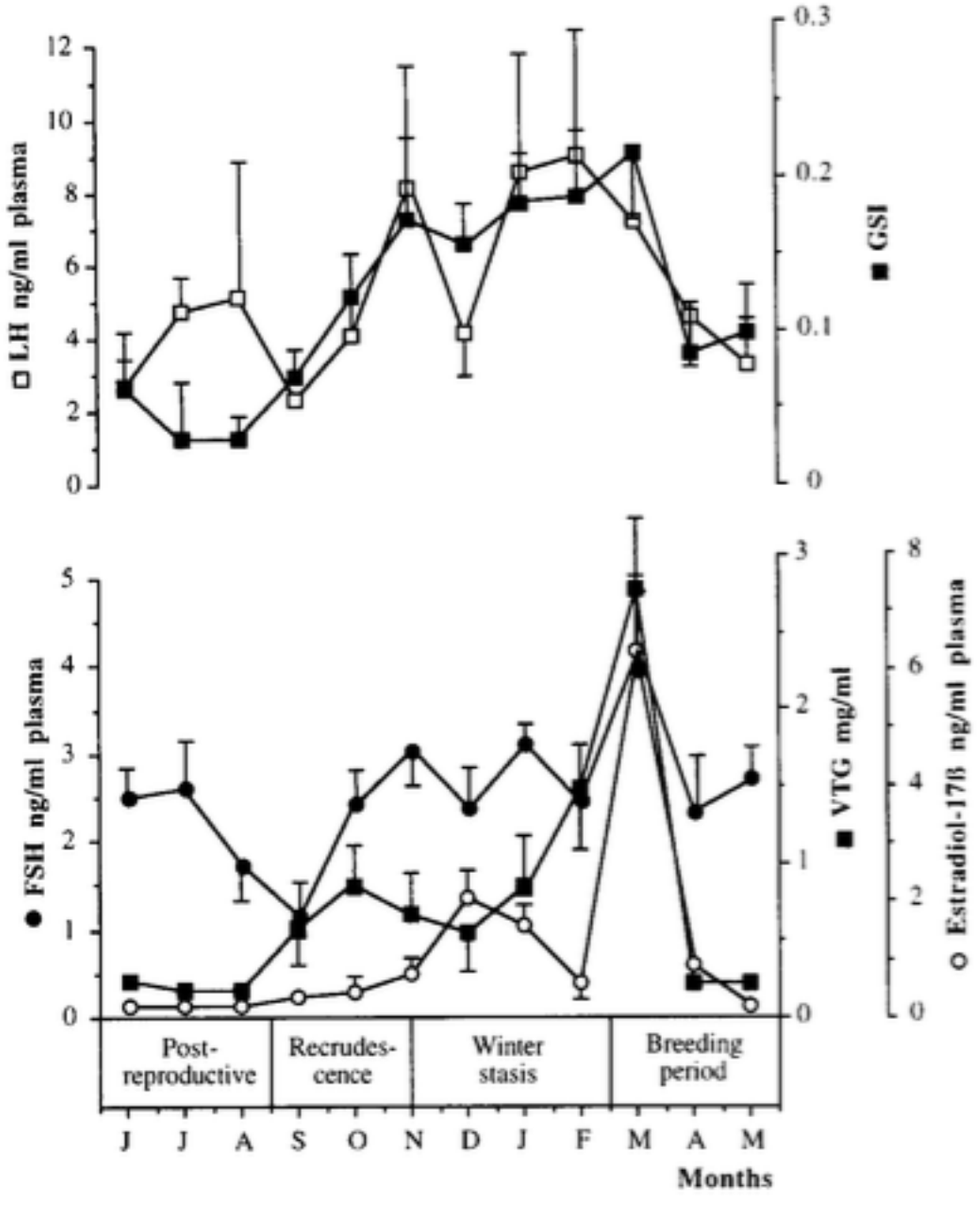


FIG. 3. Seasonal changes in LH plasma levels and GSI in female *R. esculenta* (upper panel); plasma VTG, E_2, and FSH levels (lower panel). Results are expressed as mean (± SD) of values obtained from 6 animals.

Eleutherodactylus bransfordii (Craugastor)

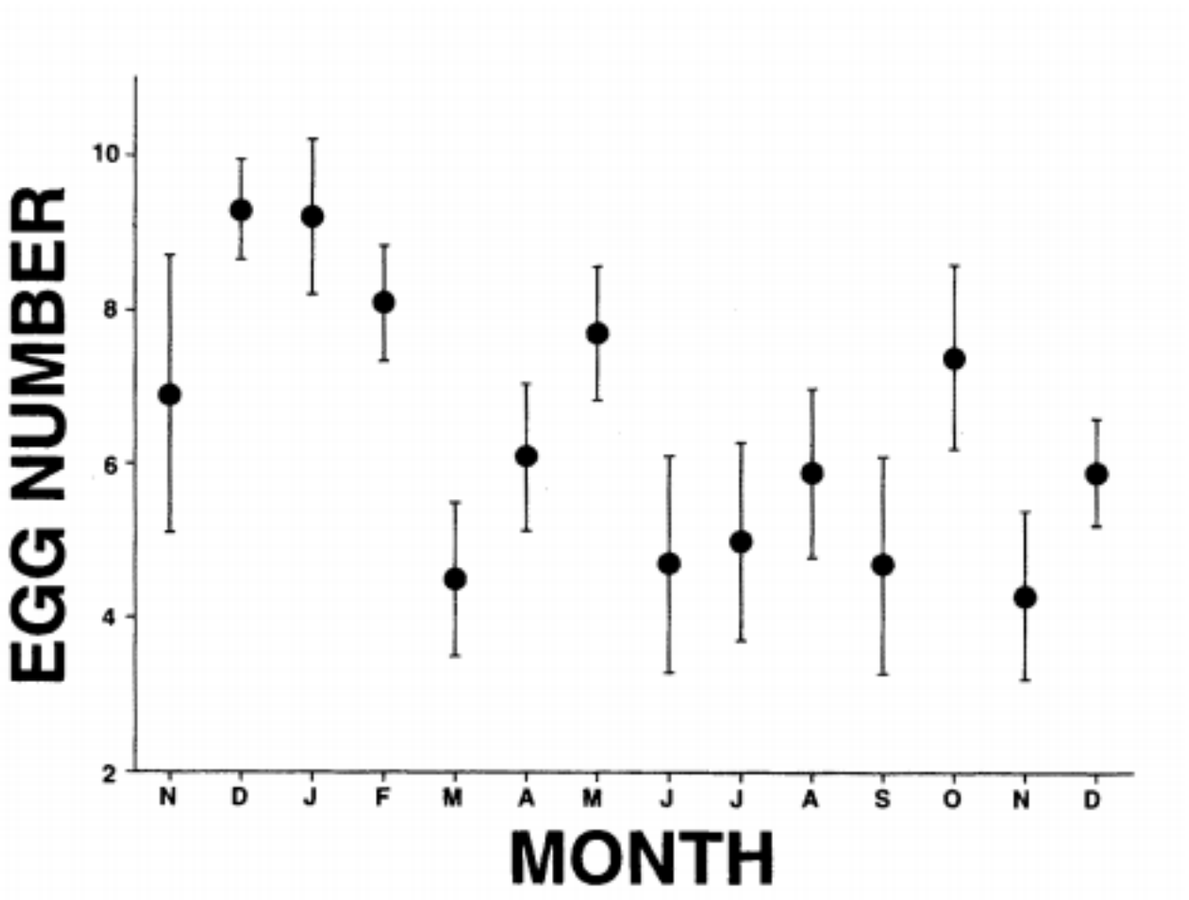


FIG. 4. Monthly variation in ovarian complement size (egg number) in *Eleutherodactylus bransfordii*. The circle indicates the mean and vertical lines indicate one standard error of the mean.

Table 1. Anuran species registered for the southern Pantanal, Brazil, their reproductive modes, reproductive patterns (E = explosive; C = continuous; P = prolonged), and reproductive period based on calling males and/or presence of gravid females and clutches (black bars), or only on gravid females (grey bars). Reproductive period refers to all reproductive episode registered for each species from January 1995 to December 1998.

Species	Mode	Pattern	Reproductive period
Bufonidae			
Bufo sp. 1 (gr. *granulosus*)	1	E	
Bufo sp. 2 (gr. *granulosus*)	1	E	
B. schneideri	1	E	
Hylidae			
Hyla nana	1	C	
H. punctata	1	P	
H. raniceps	1	P	
Lysapsus limellus	1	C	
Phrynohyas venulosa	1	E	
Phyllo medusa hypochondrialis	18	P	
Pseudis paradoxa	1	P	
Scinax acuminatus	1	E	
S. fuscomarginatus	1	P	
S. nasicus	1	E	
Leptodactylidae			
Adenomera cf. *diptyx*	21 or 22	P	
L. eptodactylus chaquensis	8	E	
L. elenae	21	P	
L. fuscus	21	P	
L. cf. *macrosternum*	8	E	
L. podicipinus	3	C	
Physalaemus albonotatus	8	P	
P. cf. *biligonigerus*	8	E	
Pseudopaludicola cf. *falcipes*	1	E	
Microhylidae			
Chiasmocleis mehelvi	1	E	
Elachistocleis cf. *bicolor*	1	E	
		Months	J F M A M J J A S O N D

Reproductive modes: (1) eggs and exotrophic tadpoles in lentic water; (8) foam nest and exotrophic tadpoles in lentic water; (18) eggs on leaves above water; exotrophic tadpoles in lentic water; (21) foam nest in subterranean chamber; exotrophic tadpoles in lentic water; (22) foam nest in subterranean chamber; endotrophic tadpoles inside the chamber (Duellman and Trueb, 1986); (8a) eggs and early larval stages in foam nests in basins constructed by males; exotrophic tadpoles in lentic water (Prado et al., 2002).

Across species, one can see a wide variety of complex patterns.

Across species, one can see a wide variety of complex patterns.

The common ground is an **interaction between external stimuli and reproductive physiology**, mediated by hormones.

example - asynchronous garter snakes

https://www.youtube.com/watch?v=VVgReLN2g8k

Mate in spring upon emergence from hibernacula

Mate in spring upon emergence from hibernacula

Males produce sperm in **summer**, store for next year

Mate in spring upon emergence from hibernacula

Males produce sperm in **summer**, store for next year

Females store sperm also, use to fertilize eggs in summer

Fertilization varies across herps

Internal vs. External Fertilization

- **External fertilization** occurs outside the females body
  - Found in most frogs and some salamanders (and all fish)
  - Affects patterns of mating and sexual selection


Photo: Sandilya Theuerkauf

Amplexus

the main mode of external fertilization in amphibians

Wood frogs (*Rana sylvatica*) in amplexus

Crazy Amplexus

- 

Atelopus varius (Bufonidae)

Crazy Amplexus, p. II

Breviceps adspersus

https://www.youtube.com/watch?v=mISMwN-0ggE

Internal vs. External Fertilization

- **Internal fertilization** occurs inside the females body
  - Found in all caecilians, most salamanders, two frogs, and all reptiles (and mammals)
  - Requires a way to get sperm inside the female's body

Internal Fertilization - Amphibians

- Evolved independently several times
- Three mechanisms:
  - –Copulatory organ (tailed frog, *Ascaphus trueii*)
  - –Cloaca to cloaca (a few other anurans)
  - –Spermatophore (many salamanders)

Gymnophiona

- *phallodeum* (male copulatory organ)

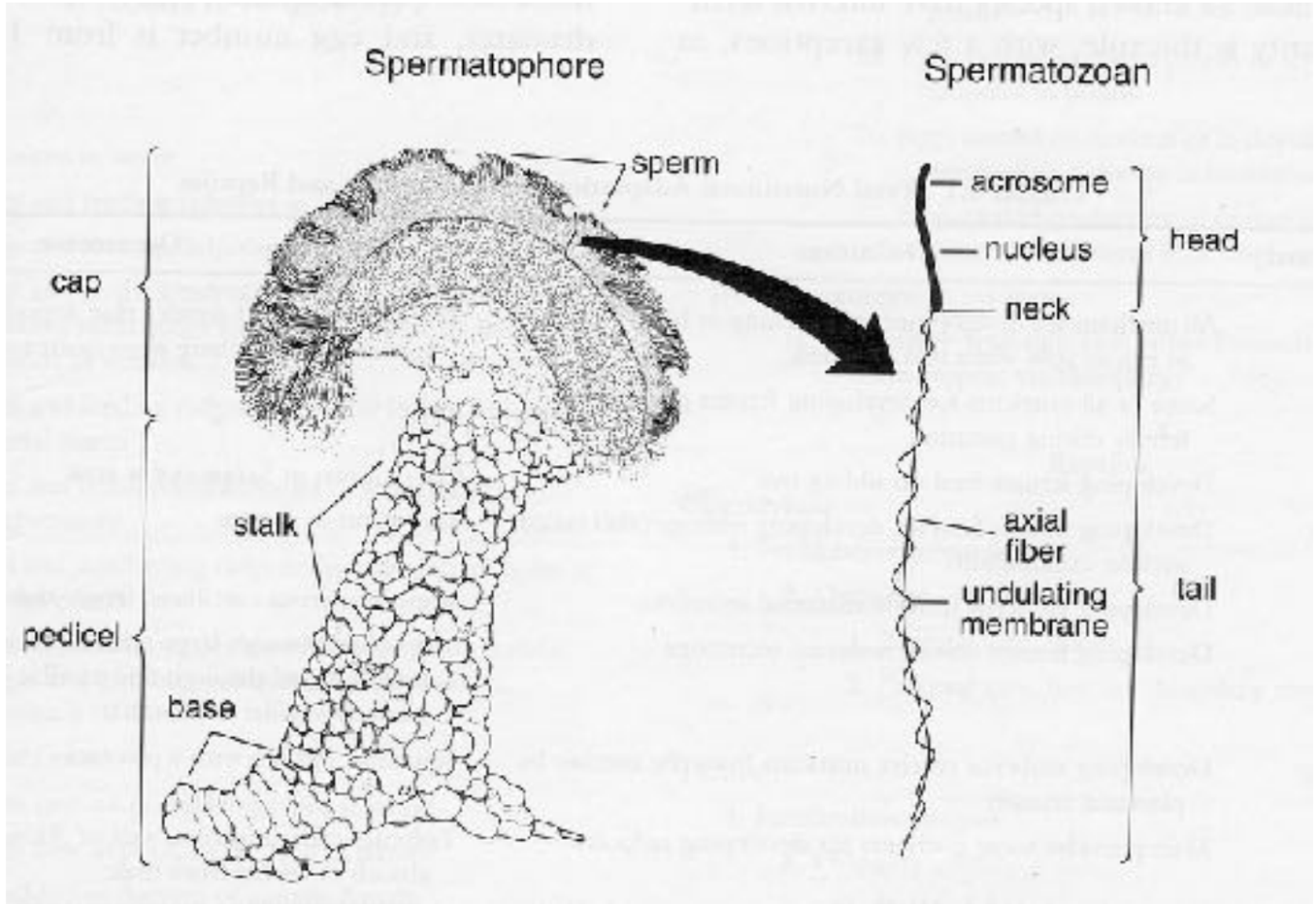
Ascaphis: Tailed frogs

- The “tail” is a copulatory organ used for internal fertilization

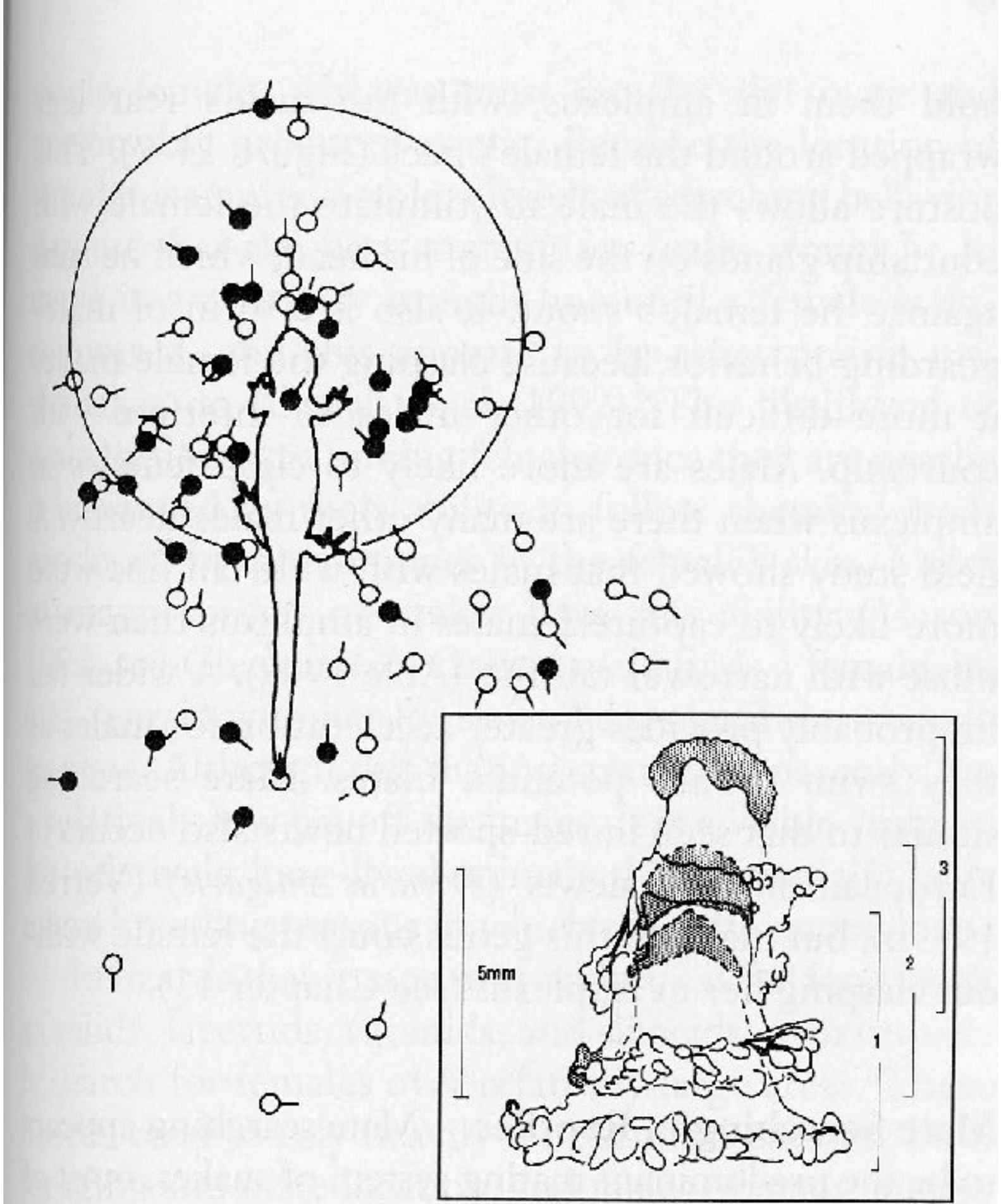
FIG. 2.—A pair of *E. coqui* in the reverse hind leg clasp. Note the mottled legs of the female on top of the male's, whose heels are visible below. Photographed at 0730 h; oviposition began at 0910 h.

Salamander Spermatophores

- Found in salamanders with internal fertilization
- Males produce gelatanous **spermatophores**
- Females pick them up, insert into cloaca



https://www.youtube.com/watch?v=xb4OiribLfI

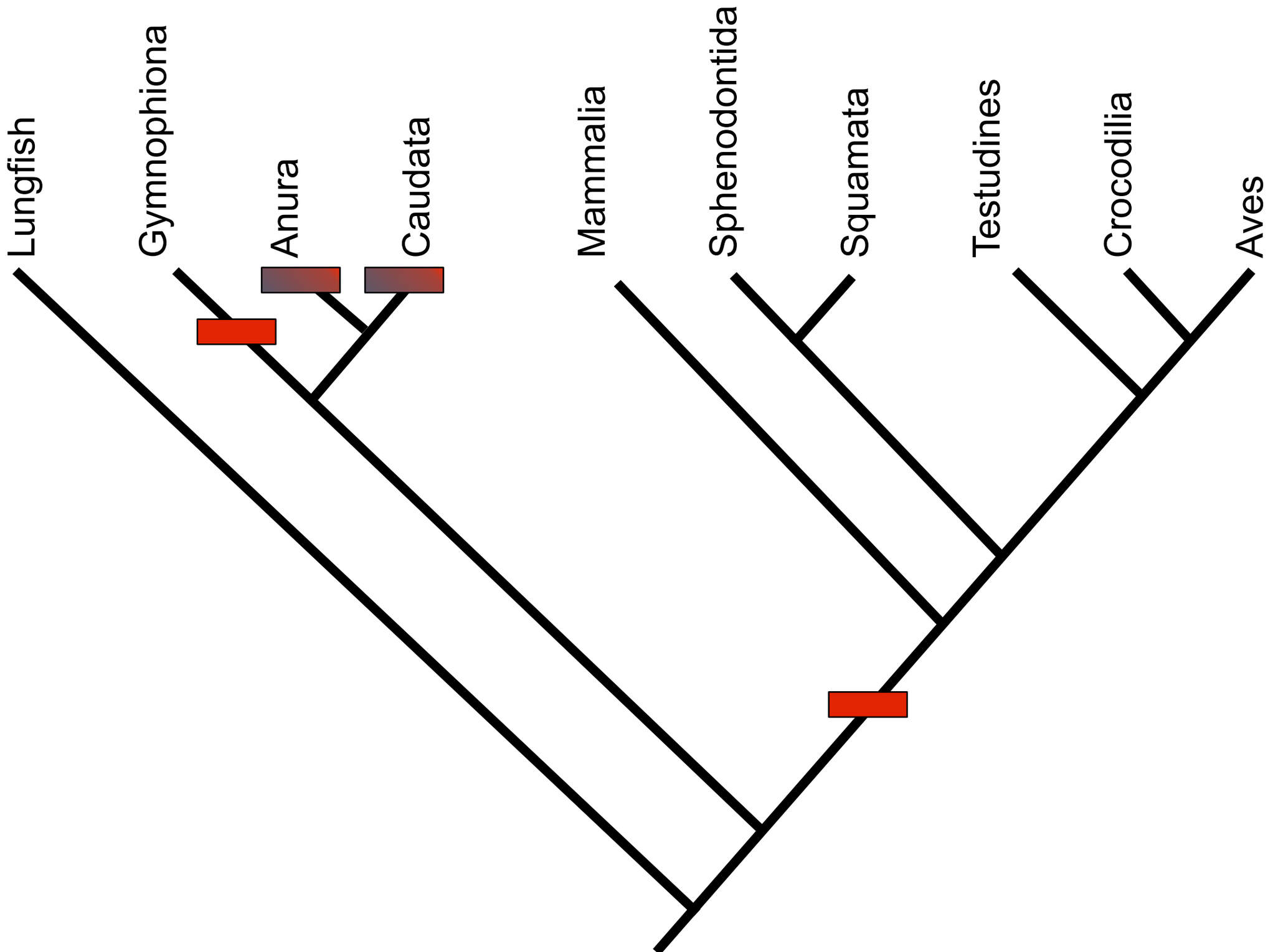

5mm
1
2
3

Internal Fertilization in Reptiles

- Male tuatara has no intromittent organ; use cloacal apposition
- Male squamates have hemipenes: paired intromittent organs
- Male turtles and crocodilians have a penis

Bioga dendrophila

Internal Fertilization



Reproduction

- **Egg to zygote:** How do eggs get fertilized?
- **Zygote to juvenile**: What are the different herp reproductive modes?

Amphibian nesting

- Amphibians show a wide variety
- Many lay jelly-covered eggs in an aquatic habitat
- But, there are other possibilities…

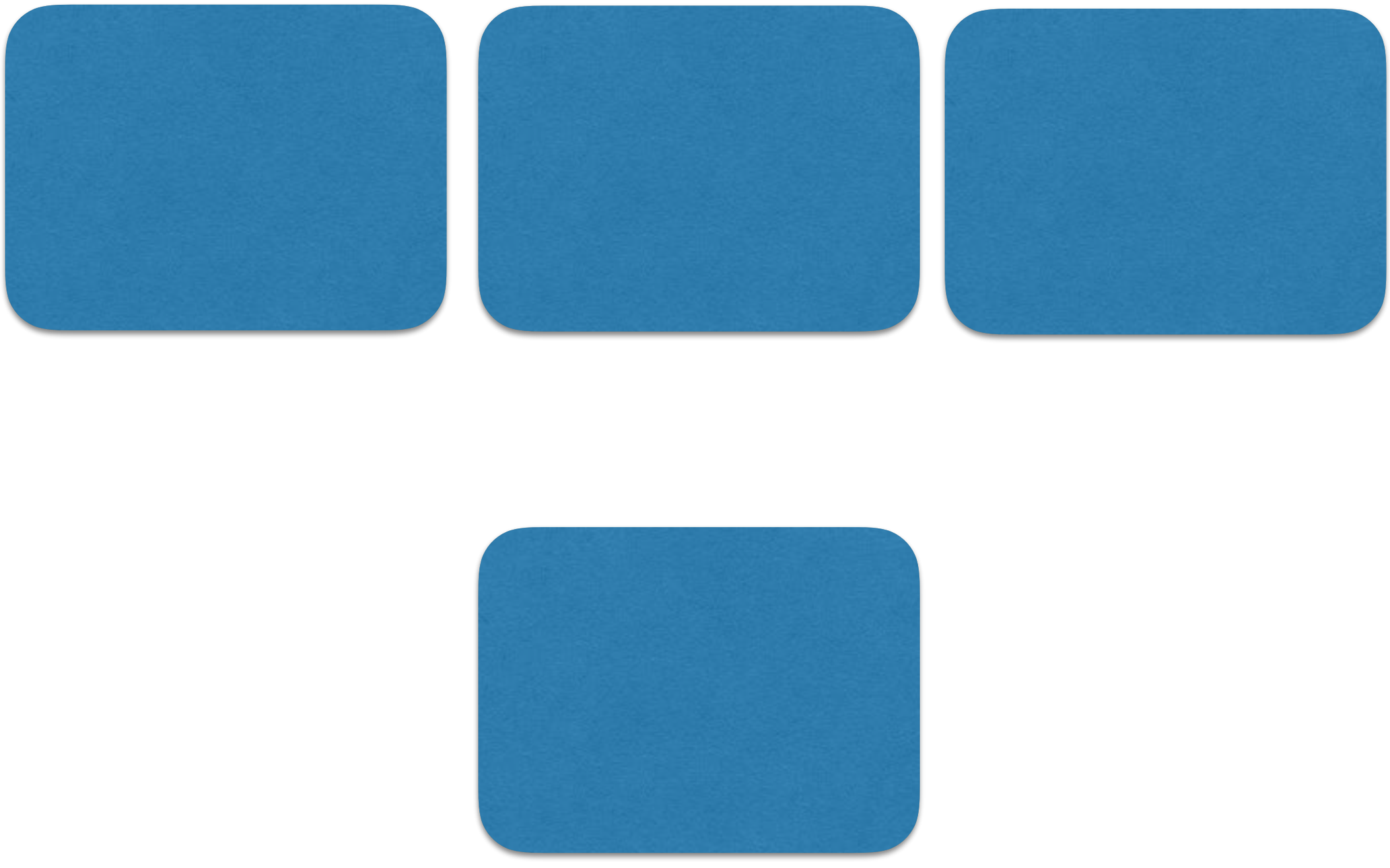
Eggs

Aquatic | Terrestrial | Arboreal

Larvae

Aquatic

Terrestrial



Eggs

Larvae	Aquatic	Terrestrial	Arboreal
Aquatic			
Terrestrial			

Rana pipiens

Eggs

	Aquatic	Terrestrial	Arboreal
Larvae: Aquatic			
Terrestrial			

Leptopelis natalensis

Eggs

Larvae	Aquatic	Terrestrial	Arboreal
Aquatic			
Terrestrial			

African Foam-nest Frog (*Chiromantis sp.)*

https://www.youtube.com/watch?v=azJGGd9FFnE

Eggs

Larvae	Aquatic	Terrestrial	Arboreal
Aquatic			
Terrestrial			

Moss froglet (*Crinia nimbus*)

Terrestrial nest, larvae hatch, develop in nest and emerge as adult frogs

Terrestrial-nesting amphibians are limited to humid environments

Some species are
even stranger…

Female deposits aquatic eggs and then swallows them

Eggs develop in her stomach, and fully formed froglets emerge from her mouth after several months

Gastric-brooding frog
Rheobatrachus silus

Female deposits aquatic eggs and then swallows them

Eggs develop in her stomach, and fully formed froglets emerge from her mouth after several months

Gastric-brooding frog

Rheobatrachus silus

EXTINCT

Other modes

- Nests can be:
  - –underground
  - –in water-filled basins
  - –in a cavity beneath vegetation
  - –eggs retained in frog’s body
- Tadpoles can sometimes:
  - –Metamorphose inside egg
  - –Be carried around by mother or father

Many species have **direct development**, where the larval stage is skipped entirely

Pristimantis gaigei

Reptile nesting

- Most egg-laying reptiles construct nests for egg deposition
- Buried, or can be under rocks or logs, glued to leaves

Reptile nesting

- Some reptiles give live birth
- Usually nutrients for young are provided by yolk, but sometimes can come from mother (matrotrophy) via a placenta

Evolution of Viviparity

- Viviparity has evolved >100 times in reptiles and amphibians
- Provides more control over reproduction, more protection, larger offspring
- Energetic costs to the mother

Asexual Reproduction

- Most species of reptile and amphibian undergo "normal" sexual reproduction
- At least 50 species undergo unisexual reproduction
- Includes salamanders, frogs, and squamates

Parthenogenesis

Parthenogenesis

- Parthenogenesis occurs when females reproduce without the involvement of males or sperm
- Inheritance is clonal
- All individuals are females

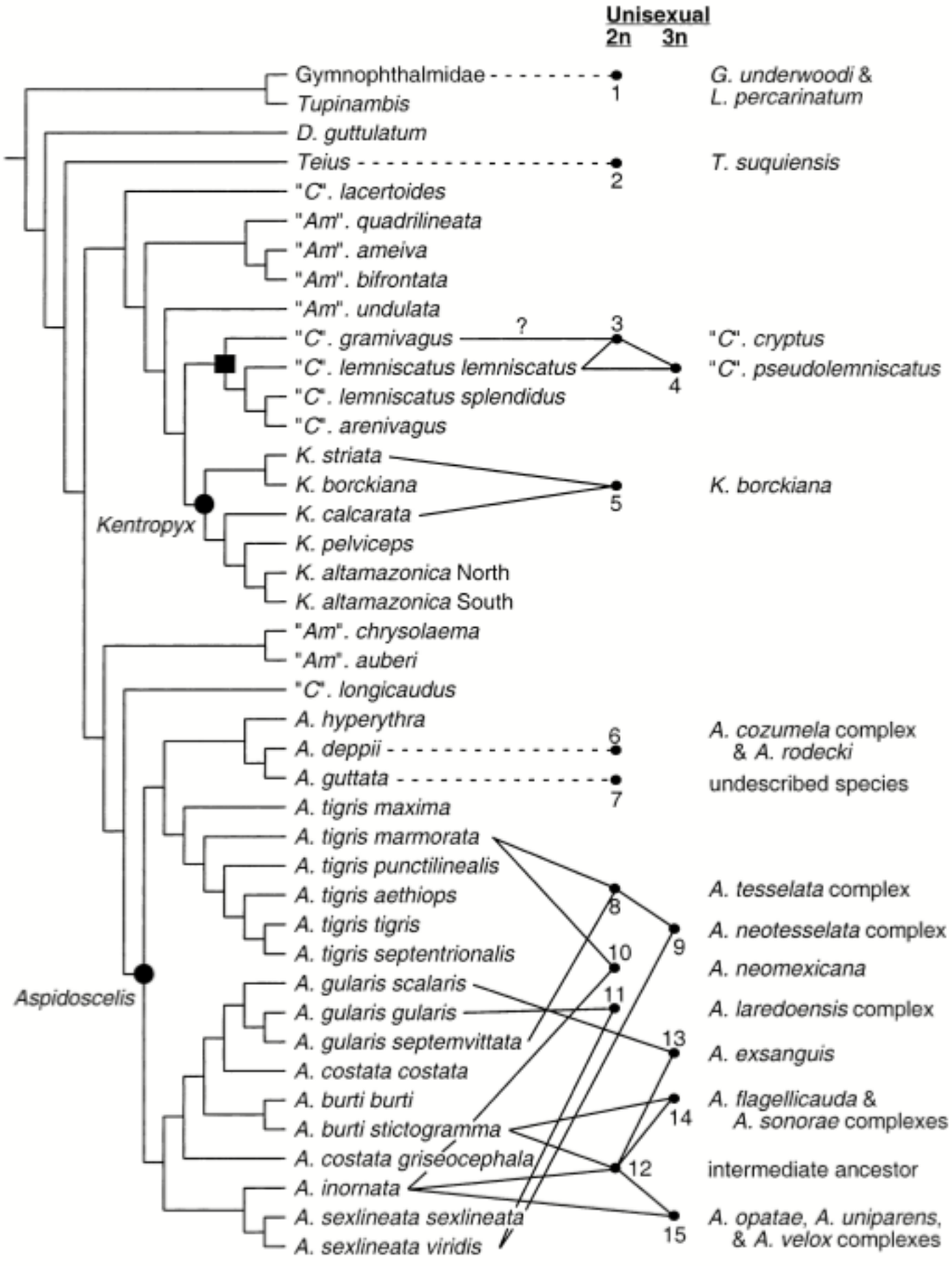
Parthenogenesis

Parthenogenesis

- All known parthenogens are hybrids between two sexual species or the result of hybridization following by backcrossing

Hybrid origins of parthenogenic teiid and gymnophthalmid lizards

from Reeder et al. 2002



Dragon virgin births startle zoo keepers

Non-sexual reproduction could lower the fitness of captive animals.

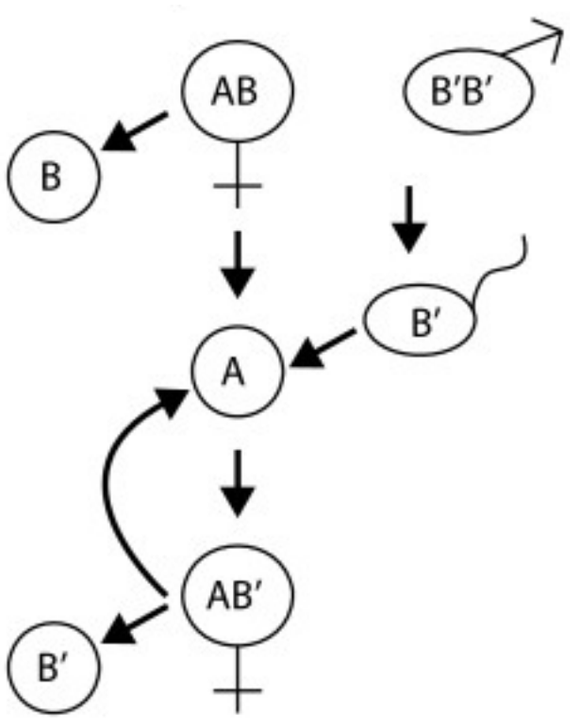
Kerri Smith

A nativity story with a twist is playing out this Christmas in two zoos in the UK. At Chester Zoo, a Komodo dragon named Flora awaits the birth of eight babies, and another four dragons have already hatched at London Zoo — each and every one the product of a virgin conception.

The miraculous births, which are all males, could be a product of keeping this threatened species in captivity, say researchers, and could have implications for the continued health of zoo-bound populations.

Virgin birth: this baby boy has no father. *I. Stephen*

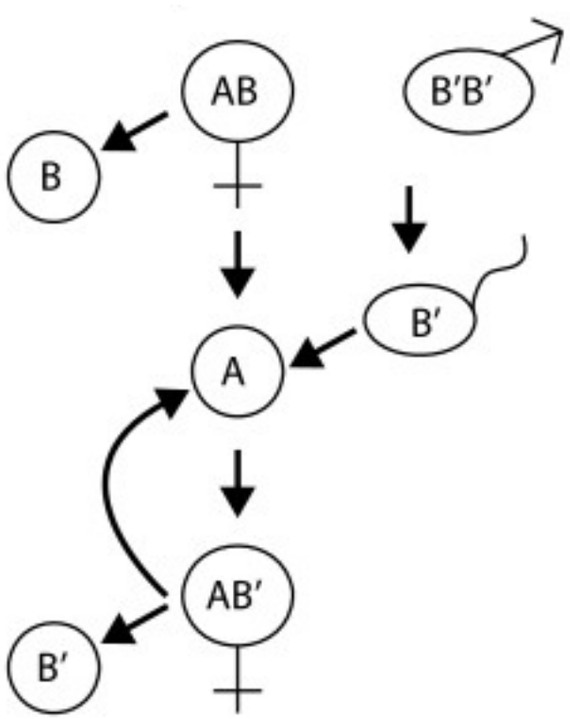
Hybridogenesis



Hybridogenesis

- In species with hybridogenesis, half of the parental genome is passed on while the other half is not
- Known from the *Rana esculenta* complex

Hybridogenesis



Hybridogenesis

- *R. esculenta* continuously form as hybrids between *R. lessonae* and *R. ribunda*
- Some diploid, some triploid
- Frogs eliminate half of the genome when mating

Parents Gametes

Parents

R. ridibunda (R)

Gametes

R

R

Parents

R. ridibunda (R)

x

R. lessonae (L)

Gametes

R

R

L

L

Parents

R. ridibunda (R)

x

R. lessonae (L)

Gametes

R

R

L

L

R. esculenta
(LR or LLR)

when e*sculenta* and *lessonae* occur together....

when *esculenta* and *lessonae* occur together....

R. esculenta
(LR or LLR)

L

R

when *esculenta* and *lessonae* occur together....

R. esculenta

(LR or LLR)

x

R. lessonae (L)

L

R

L

L

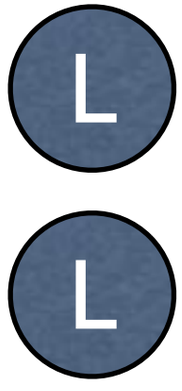
when *esculenta* and *lessonae* occur together....

R. esculenta

(LR or LLR)

x

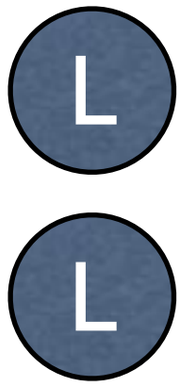
R. lessonae (L)



when *esculenta* and *lessonae* occur together....

R. esculenta
(LR or LLR)
x

R. lessonae (L)



R. esculenta
(LR or LLR)

when *esculenta* and *ridibunda* occur together....

when *esculenta* and *ridibunda* occur together....

R. esculenta
(LR or LLR)

L

R

when *esculenta* and *ridibunda* occur together....

R. esculenta

(LR or LLR)

x

R. ridibunda (R)

L

R

R

R

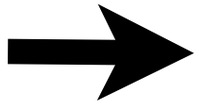
when *esculenta* and *ridibunda* occur together....

R. esculenta

(LR or LLR)

x

R. ridibunda (R)



when *esculenta* and *ridibunda* occur together....

R. esculenta
(LR or LLR)
x

R. ridibunda (R)

L

R

R

R. esculenta
(LR or LLR)

what about interbreeding?

what about interbreeding?

R. esculenta
(LR or LLR)

L

R

what about interbreeding?

L

R

R. esculenta
(LR or LLR)
x

L

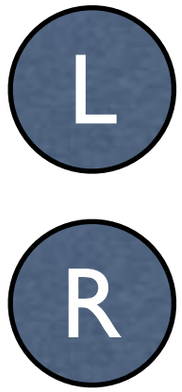
R

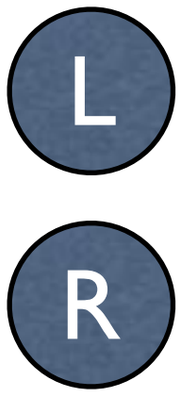
R. esculenta
(LR or LLR)

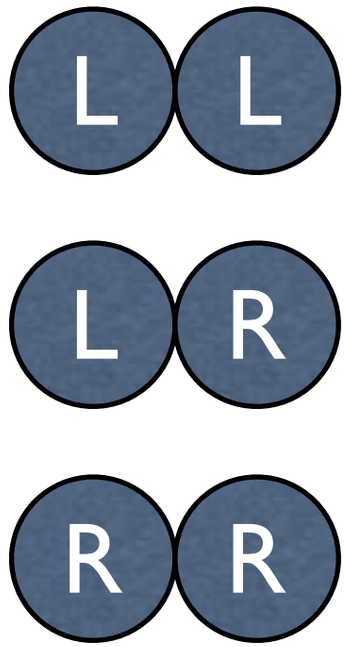
what about interbreeding?

R. esculenta
(LR or LLR)
x

R. esculenta
(LR or LLR)



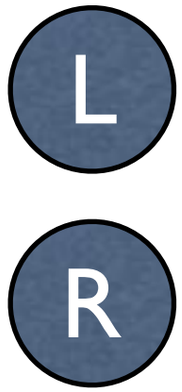


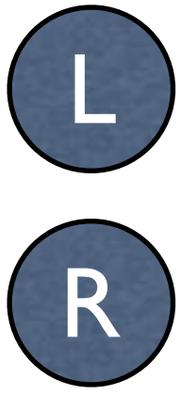


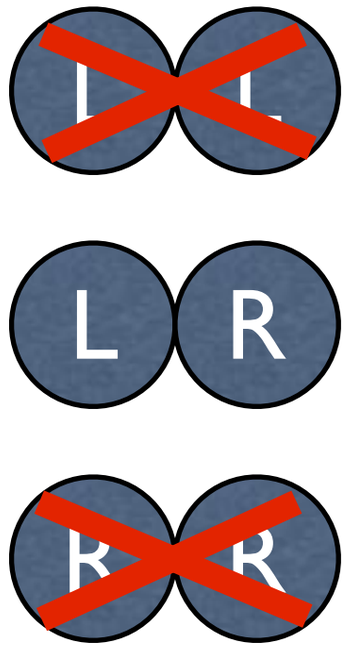
what about interbreeding?

R. esculenta
(LR or LLR)
x

R. esculenta
(LR or LLR)







what about interbreeding?

R. esculenta
(LR or LLR)
x

R. esculenta
(LR or LLR)

L

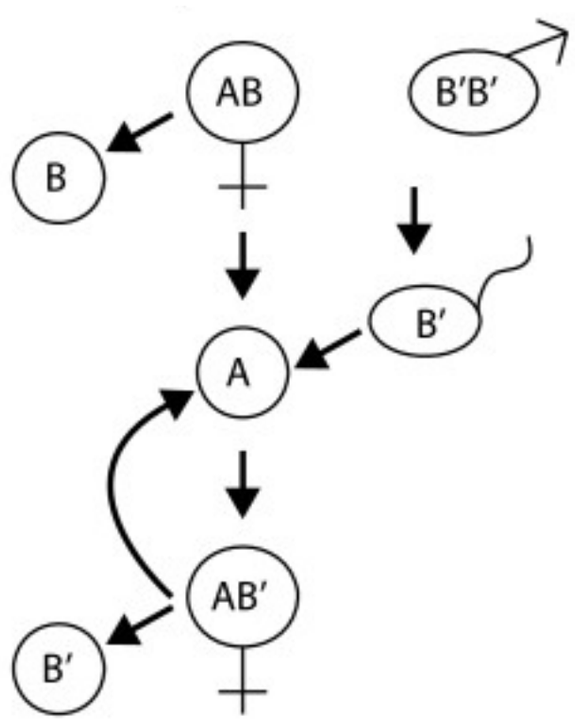
R

L

R

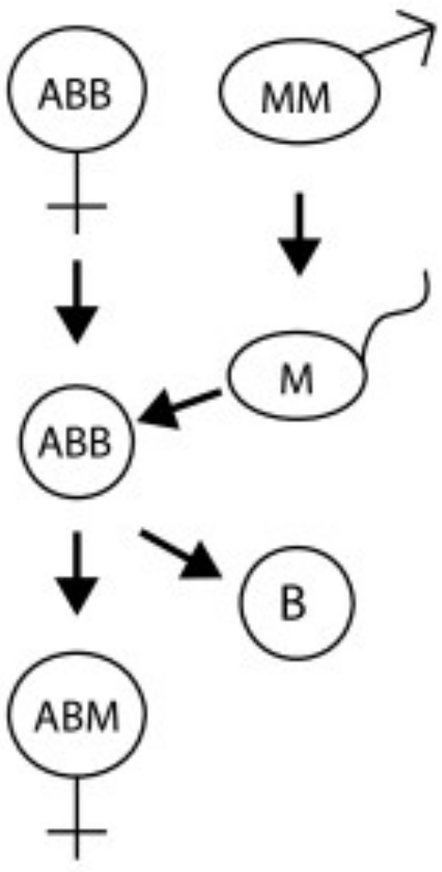
R. esculenta
(LR or LLR)

Hybridogenesis



Hybridogenesis

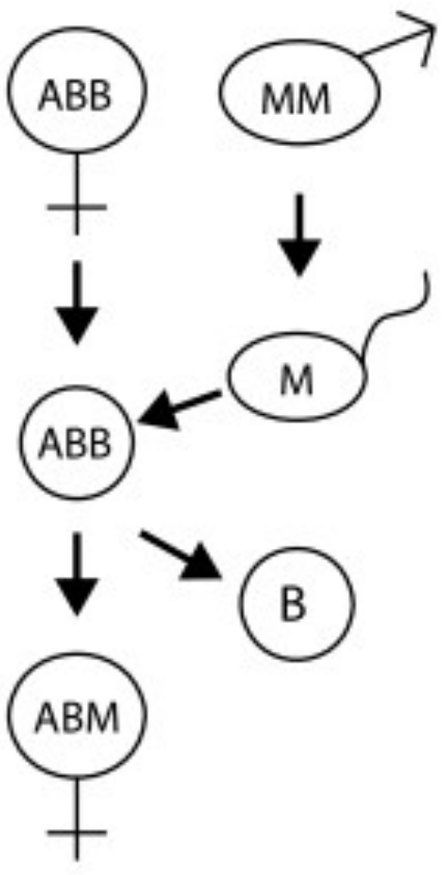
Kleptogenesis



Exchange of genetic material: Kleptogenesis

- Found in salamander species in the *Ambystoma laterale-jeffersonium* complex
- Polyploid unisexual species "borrow" whole genomes from local species
- Lineages trade out stolen genomes from time to time

Kleptogenesis



Exchange of genetic material: Kleptogenesis

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- **Egg to zygote:** How do eggs get fertilized?
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